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Optimization of Network Fast Flow Based on Anti-ant Colony Optimization

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Abstract

There are fewer research results of optimizing the network fast flow by relative optimal path in the links. This paper presents a conception of link capacity based on the foundation of concept convergence expectation and convergence gradient. Based on the convergence gradient, the relatively optimal path is used to analyze problem in a reverse perspective of ant colony algorithm, which is also called anti-ant colony algorithm. According to the pheromone strength and rate of flow, the link makes a second judgment to decide the route. In this way, the load balance rate of the flow achieved and the congestion of the network can be avoided. Experimental results show that the method achieved link load balancing and the network resources utilization coefficient can be improved.

Keyword. Ant Colony Optimization, Network Fast Flow, Optimal Path

1. Introduction

In the current development of practical engineering, users put forward their demand for a higher quality of service requirement. It becomes the primary target to reduce congestion between the points, efforts to improve the coefficient of resources utilization, and provide a higher QoS assurance for the terminal user

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[1]. These requirements requires not only broadband access networks but higher network bandwidth, have the ability to provide differential service to satisfy the demand of user and application [2]. From the current network technology development, the growth of network bandwidth is much higher than the growth in processor speed and memory access rate, server will become a bottleneck in the network transmission, via high-performance local area network or internet through the server cluster is a effective structure which can provide highly scalable and available network services [3]. The core network equipment already unable to afford the data flow and growing strength calculation of the current situation separately. So how to optimize the control of the flow reasonably is becoming a TE(Traffic Engineering) research hotspot [4-5].

Bio-inspired mechanisms have increasingly been applied to network study. The ant-colony algorithm is a biological heuristic optimization method to simulate intelligent path selection in search of food. Researchers have tried different methods of network traffic optimization. Lu Jun [6], for the network resource management for load balancing and optimization, combines ant colony algorithm and network traffic engineering together, proposed a dynamic network load balancing method based on multi-ant colony. This method realizes the optimization of network resources. Ding Jianli[7] proposed hybrid ant algorithm realizes network resource equilibrium method, get the optimal solution by combining genetic algorithm and ant colony algorithm. Chen Junjian [8] and his teammate give up the way to find path in probability but use the method to find the path of node which is less in ant pheromone when ant finding the path. And this method solves the QoSR problem.

But researches below have no necessary consideration and analysis of relatively optimal path utilization to the link. This paper analyzes the link by anti-ant colony, and designs an anti-ant colony algorithm to optimize the network fast flow.

2. Link select of anti-ant colony analyzes

Ant colony decide the path by the strength of pheromone with no consider of Link load-sharing mechanisms. As a result, the path congestion leads to overall performance degradation of the network.

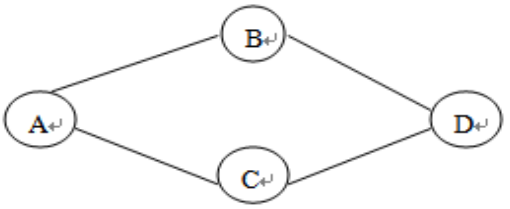

Figure 1. Simple topology of ant path-finding

Figure 1 shows a simple topology graph structure to describe the case that ant find the optimal path. The ant has 3 ways can choice from node A to node D, AD, ACD, ABD. Assuming ants from node A when beginning in accordance with the pheromone strength to select the route, then, the route with the highest pheromone strength have the biggest probability to be selected. Assuming at first, the pheromone strength on the 3 path is equal, ant will reach D from all three ways. Because of the length of 3 path is not equal, they will arrive D at different time, when ants start from A again, the pheromone strength on path AD is higher than the other two path, the probability ants select path AD will increase. With the increase in the number of ants select, the pheromone on path AD will increase at the same time. Then, about all of ants select path AD but not path ACD or ABD. The result is too many ants gathering on the path AD caused congestion, and resources are wasted.

Based on the analysis above, as the network traffic in the path transporting in the presence of competing, all the scholars realize a fair share bandwidth of network flow through the network engineering congestion control theory [10]. Network load balancing problem can be described as to find a serious of nodes in the network to constitute a path group. The method in support network load balancing network traffic under the premise of effective support network flow to avoid congestion.

This paper optimizes the network flow by improved ant colony algorithm. The algorithm firstly expand the ant colony algorithm to anti-ant colony algorithm, ants select the path by considering both pheromone strength on the path and optional link's load. This method improved the efficiency for it distributes ants uniformly in the optional link and it can avoid idle or over congestion of the link.

3. Principle of anti-ant colony algorithm

Let G＝（V，E）a connected undirected graph with n nodes and m edges, V(G) a set of its vertices, any vertex $v_i \in V$, E(G) is edge set is link set, to any link $e_i \in E$, let n=|V|，N=|E|, Ci is the capacity of link ei, i={1，2，，，，N }. Li is the truly flow of link ei. Graph G's vertex v_i have load $w_i^0 \geq 0$, the aim of load balancing algorithm is to decide the load balancing vector w^l makes

$$w^l = (\frac{1}{n}\Sigma_{i=1}^{n} w_i^0)(1,1,...,1)^T \quad (1)$$

The number of ants on the link is the current flow in the process of iteration. Li means current flow of link ei. M means the amount of ants, Mi means number of ants on the link, t is number of iterations.

$$M_i = M \cdot P_i \quad (2)$$

$$L_i = M_i / t \quad (3)$$

The load capacity is the maximum data flow the link can bear in one iteration, which expressed by Ci. So the capacity of the load is called the load limit. Then the flow Li can not beyond the load capacity Ci, the scope of Li is 0-Ci.

Ci reflects the transmission performance of the link and it is influenced by the bandwidth, time-delay, packet loss, so the capacity of each load is different. Setting Ci of each link in random can combine the actual situation of the network link. But Ci is fixed once it is installed.

To analyze the problem easily, a simulate three-link graph is given, capacity of each link is fixed. Allocate the pheromone of each link in random, then compare the actual flow with capacity of the link. If Li is less than Ci, the path is selected, else split a part of flow to other links. This method can get a load balancing and avoid congestion in a link. Because of the link and flow is different, in the next iteration the flow should be allocated again. As the volatilization of pheromone on each link is different which can lead to a possibility change, the flow should be reallocated, too. As each link is fixed, no matter how the flow changed, its initial allocation is based on the distribution of pheromone. After each cycle, more ants will be allocated on the link which the pheromone intensity is weak, then the pheromone intensity will strengthen. The link which the pheromone intensity is weak will allocate less ants, then he pheromone

intensity will weak. This method can avoid too many ants be allocated on one link which will causes congestion. With the cycling iteration, the flow can be allocated on each link in uniform.

4. Algorithm and experiment

The experiment simulates the ant colony algorithm under VC. Let a 4 node simple complete directed graph coordinates as data set, considering the conditions of delay and cost to study the optimal and load effect. The parameter of the algorithm m=20, a=0.999, β= 5, ρ= 1. In Figure 2 black line show the load balancing graph under cost function, the light-line shows the load balancing graph with the increasing iteration times under the delay function. The experiment data can get by the simulate network program execution. Assume that 3 links using the anti-ant colony algorithm to simulate the flow load balancing.

The Anti-ant colony optimization algorithm is introduced as follows:

- Step1: Initialize the parameter. Let time t=0 and the cycle-index Nc=0, set the max cycle-index Ncmax.
- Step2: Set m ants start out from node A to node D, 3 paths can be selected, allocate pheromone, link cost and link load capacity randomly to 3 links.
- Step3: Ants ensure selection possibility by the pheromone on the link to decide which link to select.
- Step4: Cycle Nc-Nc+1 times.
- Step5: Judgment whether the link flow over the limit of the link load capacity, if not, select this link, else allocate ants to other links. Calculate the utilization factor of each link. Repeat step 2.
- Step6: If the end condition which means that cycle-index Nc>Ncmax is satisfied, the loop end and output the result which based on the current utilization factor of the link.

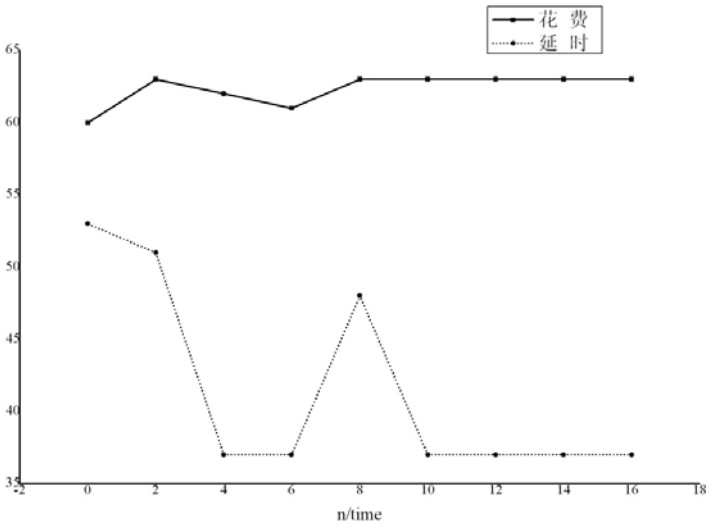

Figure 1 Renderings of anti-ant colony algorithm optimization

Figure 1 show that the cost curve of anti-ant colony algorithm is steady and find the optimal path in short time. Although fluctuations of delay curve slightly larger, the time delay is smaller when the curve is steady. The experiment shows that when QoS can be satisfied the anti-ant colony algorithm can optimize the router and realize flow balancing at same time.

5. Conclusion

In this paper, an anti-ant colony algorithm realize flow balancing based on the foundation by the introduction of convergence and convergence of expectations. Based on the pheromone on the link when ants find the optimal path to estimate the load condition on the network link, when the pheromone on the link is high allocate less flow, otherwise allocate much flow. The experiment result shows that via control the pheromone on the link can realize network load balancing, it can improve the utilization factor of the network in efficient, reduce network time delay, improve the utilization factor of the bandwidth, reduce packet loss. This paper solves network load balancing based on the foundation of convergence and convergence of expectations. This method take into account both the convergence rate and achieve network load balancing. The result of stimulate experiment shows that this method can judge the flow on the network link, then allocate the flow, achieve load balancing, improved the network efficiency.

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